chemistry. Mucic et al., *Chem. Commun.*, 555 (1996); Eckstein, ed., in *Oligonucleotides and Analogues*, 1st ed., Oxford University, New York, NY (1991). The ferrocenylphosphoramidite is prepared in a two-step synthesis from 6-bromohexylferrocene. In a typical preparation, 6-bromohexylferrocene is stirred in an aqueous HMPA solution at 120°C for 6 hours to from 6-hydroxyhexylferrocene. After purification, the 6-hydroxyhexylferrocene is added to a THF solution of N,N-diisopropylethylamine and beta-cyanoethyl-N,N- diisopropylchlorophosphoramide to form the ferrocenylphosphoramidite. Oligonucleotide-modified polymer-coated gold nanoparticles, where the polymer contains electrochemically-active ferrocene molecules, could also be utilized. Watson et al., *J. Am. Chem. Soc.*, **121**, 462-463 (1999). A copolymer of amino reactive sites (*e.g.*, anhydrides) could be incorporated into the polymer for reaction with amino-modified oligonucleotides. Moller et al., *Bioconjugate Chem.*, **6**, 174-178 (1995). In the presence of target and with temperature cycling, the redox-active probe oligonucleotides will move from the satellite probe to the target. Once this has happened, application of the magnetic field will remove the magnetic particles from solution leaving behind the redox-active probe oligonucleotides hybridized with the target nucleic acid. The amount of target then can be determined by cyclic voltammetry or any electrochemical technique that can interrogate the redox-active molecule.

In yet another embodiment of the invention, a nucleic acid is detected by contacting the nucleic acid with a substrate having oligonucleotides attached thereto. The oligonucleotides have a sequence complementary to a first portion of the sequence of the nucleic acid. The oligonucleotides are located between a pair of electrodes located on the substrate. The substrate must be made of a material which is not a conductor of electricity (*e.g.*, glass, quartz, polymers, plastics). The electrodes may be made of any standard material (*e.g.*, metals, such as gold, platinum, tin oxide). The electrodes can be fabricated by conventional microfabrication techniques. See, *e.g., Introduction To Microlithography* (L.F. Thompson et al., eds., American Chemical Society, Washington, D.C. 1983). The substrate may have a plurality of pairs of electrodes located on it in an array to allow for the

detection of multiple portions of a single nucleic acid, the detection of multiple different nucleic acids, or both. Arrays of electrodes can be purchased (*e.g.,* from AbbtechScientific, Inc., Richmond, Virginia) or can be made by conventional microfabrication techniques. See, *e.g., Introduction To Microlithography* (L.F. Thompson et al., eds., American Chemical Society, Washington, D.C. 1983). Suitable photomasks for making the arrays can be purchased *(e.g.,* from Photronics, Milpitas, CA). Each of the pairs of electrodes in the array will have a type of oligonucleotides attached to the substrate between the two electrodes. The contacting takes place under conditions effective to allow hybridization of the oligonucleotides on the substrate with the nucleic acid. Then, the nucleic acid bound to the substrate, is contacted with a type of nanoparticles. The nanoparticles must be made of a material which can conduct electricity. Such nanoparticles include those made of metal, such as gold nanoparticles, and semiconductor materials. The nanoparticles will have one or more types of oligonucleotides attached to them, at least one of the types of oligonucleotides having a sequence complementary to a second portion of the sequence of the nucleic acid. The contacting takes place under conditions effective to allow hybridization of the oligonucleotides on the nanoparticles with the nucleic acid. If the nucleic acid is present, the circuit between the electrodes should be closed because of the attachment of the nanoparticles to the substrate between the electrodes, and a change in conductivity will be detected. If the binding of a single type of nanoparticles does not result in closure of the circuit, this situation can be remedied by using a closer spacing between the electrodes, using larger nanoparticles, or employing another material that will close the circuit (but only if the nanoparticles have been bound to the substrate between the electrodes). For instance, when gold nanoparticles are used, the substrate can be contacted with silver stain (as described above) to deposit silver between the electrodes to close the circuit and produce the detectable change in conductivity. Another way to close the circuit in the case where the addition of a single type of nanoparticles is not sufficient, is to contact the first type of nanoparticles bound to the substrate with a second type of nanoparticles having oligonucleotides attached to them that have a sequence complementary to the oligonucleotides on the first type of

nanoparticles. The contacting will take place under conditions effective so that the oligonucleotides on the second type of nanoparticle hybridize to those on the first type of oligonucleotides. If needed, or desired, additional layers of nanoparticles can be built up by alternately adding the first and second types of nanoparticles until a sufficient number of nanoparticles are attached to the substrate to close the circuit. Another alternative to building up individual layers of nanoparticles would be the use of an aggregate probe (see above).

The invention also provides kits for detecting nucleic acids. In one embodiment, the kit comprises at least one container, the container holding at least two types of nanoparticles having oligonucleotides attached thereto. The oligonucleotides on the first type of nanoparticles have a sequence complementary to the sequence of a first portion of a nucleic acid. The oligonucleotides on the second type of nanoparticles have a sequence complementary to the sequence of a second portion of the nucleic acid. The container may further comprise filler oligonucleotides having a sequence complementary to a third portion of the nucleic acid, the third portion being located between the first and second portions. The filler oligonucleotide may also be provided in a separate container.

In a second embodiment, the kit comprises at least two containers. The first container holds nanoparticles having oligonucleotides attached thereto which have a sequence complementary to the sequence of a first portion of a nucleic acid. The second container holds nanoparticles having oligonucleotides attached thereto which have a sequence complementary to the sequence of a second portion of the nucleic acid. The kit may further comprise a third container holding a filler oligonucleotide having a sequence complementary to a third portion of the nucleic acid, the third portion being located between the first and second portions.

In another alternative embodiment, the kits can have the oligonucleotides and nanoparticles in separate containers, and the oligonucleotides would have to be attached to the nanoparticles prior to performing an assay to detect a nucleic acid. The oligonucleotides and/or the nanoparticles may be functionalized so that the oligonucleotides can be attached to the nanoparticles. Alternatively, the oligonucleotides and/or nanoparticles may be